इंटरनेट मानक

Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

"जानने का अधिकार, जीने का अधिकार"
Mazdoor Kisan Shakti Sangathan
"The Right to Information, The Right to Live"

"पुराने को छोड नये के तरफ"
Jawaharlal Nehru
"Step Out From the Old to the New"

IS 1405 (2010): IRON ORES — SAMPLING AND SAMPLE PREPARATION — MANUAL METHOD [MTD 13: Ores and Raw Materials]

"ज्ञान से एक नये भारत का निर्माण"
Satyanarayan Gangaram Pitroda
"Invent a New India Using Knowledge"

Act Number 22 of 2005
The Indian Parliament
RIGHT TO INFORMATION

Made Available By
Public.Resource.Org

"ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है"
Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

BLANK PAGE

BRUTUM FULMEN

IGNORANTIA JURIS NON EXCUSAT

PROTECTED BY COPYRIGHT

भारतीय मानक

लौह अयस्क — नमूने एवं नमूना बनाना — हस्त पद्धति

(तीसरा पुनरीक्षण)

Indian Standard

IRON ORES — SAMPLING AND SAMPLE PREPARATION — MANUAL METHOD

(Third Revision)

ICS 73.060.10

© BIS 2010

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

May 2011 **Price Group 8**

Ores and Raw Materials Sectional Committee, MTD 13

FOREWORD

This Indian Standard (Third Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Ores and Raw Materials Sectional Committee, had been approved by the Metallurgical Engineering Division Council.

This standard was originally published in 1961 and was subsequently revised in 1966 and 1982. Since then, a lot of developments have taken place in iron ore industry and trade. With the increased capacity of ships, the tonnage of a single consignment of export from Indian ports has crossed the 2.5 lakh mark. Further handling operations have become faster thereby necessitating speed in the operations of sampling, sample operation, analysis and final estimation of quality of iron ore consignments.

In the present revision, lot sizes beyond 2.5 lakh tones have also been covered and the number of sub-lots into which a lot is to be divided has been slightly reduced taking into account the need for faster sampling operations. In addition to delivery of iron ore in trucks, which has been quite popular in some parts of the country, sampling of iron ore from barges and preparation of sample for determining physical characteristics has been introduced.

Taking into consideration the latest developments in iron ore industry and trade at national and international levels, the ores have been classified into two broad categories, namely, lumps and fines. For the purpose of sampling three sizes of lumpy ore and two sizes of fine ores are considered.

The present revision mainly deals with manual sampling of iron ores and as such cannot be employed in those cases where sample preparation are fully mechanized.

In the formulation of this standard due consideration has been given to international co-ordination among the standards and practice prevailing in different countries. For this purpose, reference has been made to the following standards:

ISO 10836 : 1994	Iron ores — Methods of sampling and sample preparation for physical testing
ISO 3084 : 1998	Iron ores — Experimental methods for evaluation of quality variation

For the determination of size distribution of iron ores, sieves conforming to IS 460 (Part 1) : 1985 ‘Specification for test sieves: Part 1 Wire cloth test sieves (*third revision*)’ and IS 460 (Part 2) : 1985 ‘Specification for test sieves: Perforated plate test sieves (*third revision*)’shall be used. When such sieves are not available, other equivalent standard sieves as judged by the aperture size may be used.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (*revised*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

IRON ORES — SAMPLING AND SAMPLE PREPARATION — MANUAL METHOD

(Third Revision)

1 SCOPE

This standard prescribes the methods for manual sampling of iron ores from conveyors, wagons, trucks, ships, stockpiles and barges for the determination of size distribution, moisture content, chemical composition, and preparation of samples for testing physical characteristics of the ore in the lot. It also lays down a method for reporting the quality of material sampled.

2 REFERENCES

The following standards contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below:

IS No.	*Title*
460	Specification for test sieves:
(Part 1) : 1985	Wire cloth test sieves (*third revision*)
(Part 2) : 1985	Perforated plate test sieves (*third revision*)
1493 : 1959	Methods of chemical analysis of iron ores
1548 : 1981	Manual on basic principles of lot sampling (*second revision*)
5842 : 1986	Methods for measuring bulk density of iron ores
8167 : 1989	Method for determination of reducibility index of iron ore oxides, lumps core, sinter and pellets (*first revision*)
9963 : 1981	Determination of shatter index of iron ore lumps, sinter and pellets
10823 : 1984	Methods for determination of thermal degradation index (TDI) and reduction degradation index (RDI) of iron oxides, lump ores, sinter and pellets
11292 : 1985	Determination of relative reducibility of iron oxides, lump ore, sinter and pellets
11690 : 1986	Method of moisture determination of iron ore lot
12550 : 1988	Methods for determining particle size distribution of iron ore fines

3 TERMINOLOGY

For the purpose of this standard, the following definitions shall apply.

3.1 Lump — Ores consisting of all sizes up to 150 mm and minimum size up to 10 mm approximately.

3.2 Fines — Ores with maximum particle size 10 mm.

3.3 Lot — The quantity of ores indicated to be of the same category (*see* **3.1** and **3.2**)and offered for inspection at one time. A lot may consist of the whole or a part of the quantity ordered for.

3.4 Sub-lot — The quantity of ore in each of the parts into which a lot is divided for the purpose of sampling.

3.5 Increment — The quantity of ore obtained by a sampling device at one time from a lot or sub-lot.

3.6 Unit Sample — The quantity of ore collected at one point in sectional sampling or at one time from the conveyer by stopped belt method.

3.7 Gross Sample — Sample as collected from a sub-lot, that is, the quantity of ore consisting of one or several increments or unit samples taken from a sub-lot.

3.8 Size Sample — The sample taken for the determination of the size distribution of the lot or sub-lot.

3.9 Laboratory Sample (Sub-lot) — The quantity of ore obtained by reducing a gross sample following a specified procedure and intended for laboratory testing.

3.10 Moisture Sample — The sample to be used exclusively for the purpose of determining moisture content.

3.11 Composite Sample for the Lot — The quantity of ore obtained by mixing together equal quantities of the ore, at appropriate stage of sample preparation from each of the sub-lot laboratory sample or physical test sample. When sub-lots vary in mass, quantities of laboratory samples or physical test samples proportionate to the sample of the sub-lot may be taken and mixed together.

NOTE — Whenever preparation of sub-lot laboratory samples is not required, the composite sample for the lot can be prepared by mixing gross samples — 10 mm stage in proportion to sub-lot tonnages.

3.12 Manual Sampling — The collection of sample increments by human effort.

3.13 Physical Test Sample — The sample to be used for the determination of physical characteristics of the ore.

3.14 Maximum Particle Size — Particle size expressed in terms of the size aperature of the sieve on which approximately 5 percent in mass of the ore is retained.

3.15 Whole Through Sieve Size — The size of the smallest aperature through which all of the sample passes.

4 GENERAL

4.1 Sub-lots

For the purpose of sampling, a lot shall be divided into a number of the sub-lots of approximately equal mass as specified in Table 1.

NOTE — When it is not practicable to have sub-lots or approximately equal mass, sub-lots with varying mass may also be permitted.

4.1.1 A representative gross sample shall be drawn from each of the sub-lots and shall be kept separately. There will be as many gross samples as number of sub-lots. The sample shall be preserved in water-proof containers and closed with suitable lids, as soon as they are drawn. The containers shall not be exposed to heat thereafter.

Table 1 Maximum Number of Sub-lots into which a Lot is to be Divided

(*Clause* 4.1)

Sl No.	Mass of the Lot	Minimum No. of Sub-lots
(1)	(2)	(3)
i)	Up to 1 500	1
ii)	1 501-5 000	2
iii)	5 001-15 000	4
iv)	15 001-30 000	6
v)	30 001-45 000	8
vi)	45 001-70 000	10
vii)	70 001-100 000	12
viii)	100 001-150 000	15
ix)	150 001-200 000	18
x)	200 001-250 000	21
xi)	250 001 and above	27

4.1.2 Sampling shall be carried out, preferably, during shifting of a lot at the time of its delivery. The sampling shall be carried out by the method of periodic systematic sampling meaning thereby that each increment shall be taken at a specific regular interval in terms of mass throughout the whole mass of the lot and shall not be changed in the course of sampling. However, when the handling of a lot still continues even after the specified increments have been taken, increments shall continue to be taken at the same interval until the completion of handling.

NOTE — When the mass of the gross sample is expected to be less than that required quantity for the tests, the number of increments shall be increased.

4.1.3 Sampling should be carried out at the nearest possible location to the loading or discharging facilities, preferably immediately before or immediately after the point of weighing. Free fall drops during handling of lumpy ore samples shall be kept to a minimum to reduce size degradation of the ore.

4.2 Minimum Mass and Number of Increments

The mass of the increment to be taken from a sub-lot for drawing the gross sample shall be governed by the maximum particle size of the ore to be sampled. The number of increments to be taken from a sub-lot for drawing the gross sample shall be governed by the mass of the gross sampled and the mass of the increment as specified in Table 2 for various categories of ores as specified by their maximum particle sizes. This number shall be evenly distributed over the sub-lot. The increments of almost uniform mass shall be drawn with suitable sampling scoop (*see* Fig.1 and Fig. 2) at regular interval.

5 SAMPLING FROM CONVEYORS BY STOPPED BELT METHOD

5.1 When iron ore is moved on conveyors, one of the most reliable methods of manual sampling is the stopped belt method. Whenever it is practicable to stop the conveyer belt periodically, a large quantity of iron ore known as unit sample may be drawn by stopping the belt. The mass of different unit samples shall not be less than that given below and shall be collected from the full width and thickness of the ores stream over a suitable length of the conveyer. The number of unit samples to be drawn at regular interval to constitute a gross sample shall be as given below for different categories at iron ores:

Category	*Maximum Particle Size* mm	*Minimum Number of Unit Samples for Each Sub-lot*	*Minimum Mass of the Unit Sample* kg
(1)	(2)	(3)	(4)
Lumps	150	8	100
	100	6	100
	50	4	100
Fines	10	4	50
	1	4	25

5.2 In case it is not possible to stop the conveyer, increments as per Table 2 shall be collected at regular intervals at a suitable transfer point in the conveyer system taking precautions to avoid the bias in sampling.

Table 2 Minimum Mass of the Gross Sample and Minimum Number of Increments

(*Clauses* 4.2 *and* 5.2)

Sl No.	Category	Maximum Particle Size mm	Minimum Mass of Increment kg	Minimum Number of Increment	Minimum Mass of Gross Sample kg
(1)	(2)	(3)	(4)	(5)	(6)
i)	Lumps	150	8	100	800
		100	8	75	600
		50	4	100	400
ii)	Fines	10	4	50	200
		1	2.5	40	100

NOTES

1 Almost uniform mass means the variation of the increment masses is under 20 percent in terms of co-efficient of variation. This means that if the average increment mass is 8 kg, masses of the increments taken should be 8 kg ± (8 kg × 0.2) that is, within the range of 6.4 kg to 9.6 kg.

2 Homogeneity of the ore is expressed in terms of quality variation (σ_w) of the quality characteristics within strata, determined as per procedure, given in Annex A, if the (σ_w) is, found to be 'LARGE' it is necessary that the number of increments drawn shall be increased suitably.

5.3 The material collected as unit samples or increments in a sub-lot shall be aggregated and mixed together to constitute a gross sample.

6 SAMPLING DURING LOADING AND UNLOADING OF WAGONS

6.1 Sub-lots

For the purpose of sampling, all the wagons in a lot shall be divided into a suitable number of sub-lots of approximately equal mass in accordance with the requirements of Table 1.

6.1.1 A representative gross sample shall be drawn from each of the sub-lots and shall be kept separately. Thus, there will be as many gross samples as the number of sub-lots into which a lot has been divided.

6.2 In order to get a representative gross sample, the ore shall be sampled as far as possible, in a steady motion during loading or unloading of the wagon.

6.2.1 A minimum of 25 percent of the wagons shall be selected at random from the sub-lot. The number of increments to be taken from the selected wagons and mass of the increments and the gross sample shall be in accordance with Table 2. The increments shall be evenly distributed over the wagon with the view to determining the necessary number of increments that should be collected from each of the wagons of the sub-lots for making of the gross sample. These increments shall be drawn with the help of a suitable scoop (*see* Fig. 1 and Fig. 2) at regular intervals at the time of loading or unloading of the wagons.

NOTES

1 While taking the increments as described above, if a large lump is encountered at any point and cannot be taken in the scoop, it shall be picked up as such. The lump so obtained shall, however, be accounted for in the determination of the ore size distribution as given under **10** and in the reduction of gross samples as given under **11**.

2 If agreed to 50 percent of the wagons may be selected, at random, from the sub-lot, for sampling by the given method.

7 SAMPLING DURING LOADING OR UNLOADING OF TRUCKS

7.1 Sub-lots

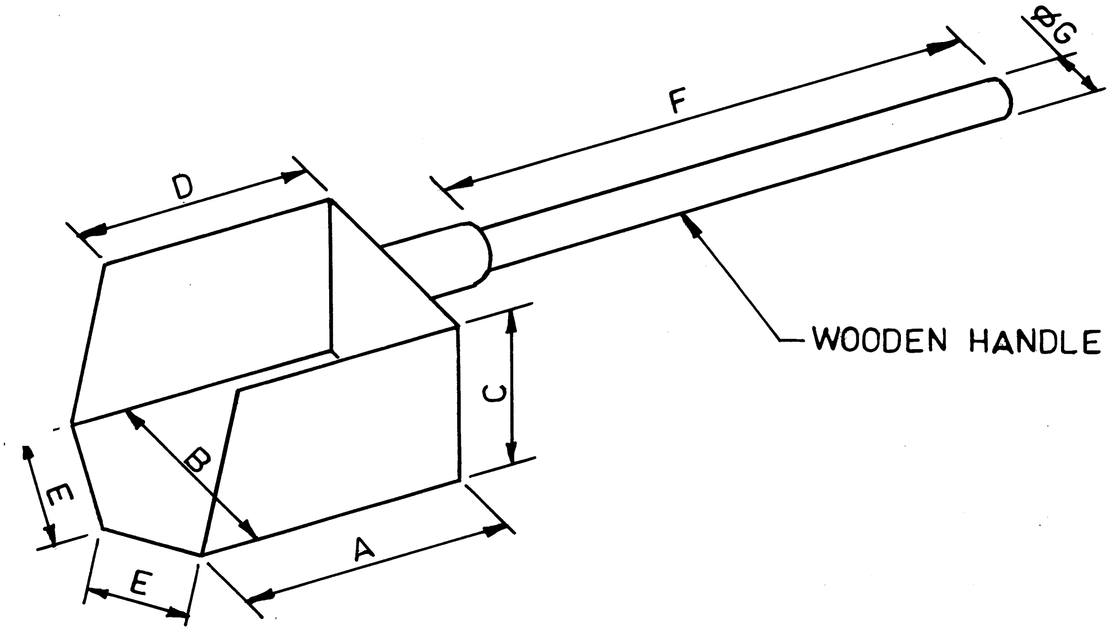
Quite often the nature of iron ore tendered in trucks is as heterogeneous as that supplied in wagons or ships and variations in terms of particle size and chemical composition has been found to be considered which requires limiting of sub-lot tonnage. Hence, when iron ore is supplied in trucks the sub-lot size shall not exceed 100 trucks counted on continuous basis. If loading or unloading is done shift-wise, sub-lots may be conveniently formed in terms of trucks handled in one shift, subject to the condition that the size of each sub-lot shall not exceed 100 trucks. Hundred percent of the trucks are to be sampled, if the ores originate from more than one source and minimum 25 percent of the trucks in the sub-lot are to be sampled, if the ore is from single source. The number of increments per truck shall be adjusted so that total number of increments from each sub-lot (100 trucks or less) is always greater than or equal to the number specified in Table 2 for various categories of ores.

7.2 In order to get representative sample, increments shall be drawn at the time of loading or unloading of the trucks. From each trucks in the sub-lot, a minimum of one increment shall be drawn. For drawing increments 8 kg or 4 kg sampling scoop (*see* Fig. 1 and Fig. 2) shall be used depending on the category of the ore. At the time of taking increments care shall be taken not to exclude deliberately lumps or fines and this will be ensured by drawing increments in the middle of loading/unloading time of a truck.

7.3 The aggregate of material collected from the various increments or unit samples from a sub-lot shall constitute a gross sample.

8 SAMPLING FROM SHIPS AND BARGES DURING LOADING/UNLOADING

8.1 For the purpose of sampling the quantity of ore to



Nominal Capacity of Scoop	Dimensions of the Sampling Scoop mm						
	A	*B*	*C*	*D*	*E*	*F*	*G*
8 kg (Lumps 200 mm and 100 mm)	200	200	100	175	115	440	40
4 kg (Lumps 50 mm and fines 10 mm)	175	120	100	100	65	350	30
2.5 kg (Fines under 1 mm)	175	120	65	155	65	350	30

Fig. 1 Sampling Scoops

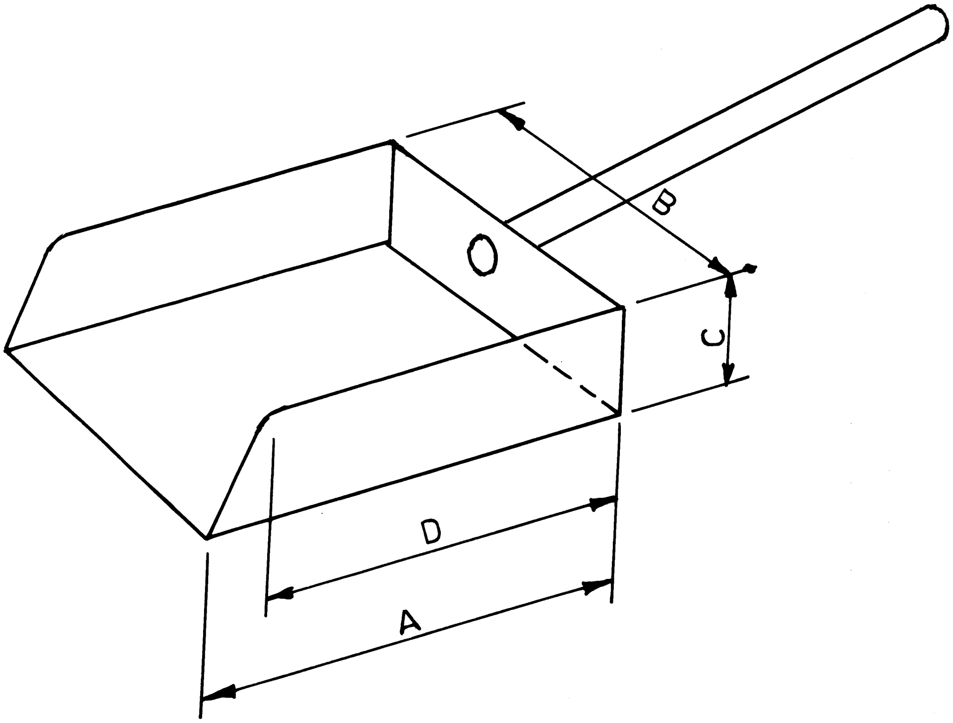


Fig. 2 Shovel for Increment Reduction

be loaded into or unloaded from ship and barges shall be divided into a suitable number of sub-lot of approximately equal mass in accordance with Table 1.

8.2 In order to get representative gross sample, ore shall be sampled as far as possible when in motion. If it is taken on a conveyer, the gross sample shall be collected according to the procedure laid down in **5**. If the ore is handled in any other manner the gross samples may be drawn during loading or unloading of the ship. For this purpose, the number of increments to be taken at regular intervals and the mass of the increments and gross sample shall be in accordance to Table 2 for different categories of ore (*see also* **6.2.1**, Note 1).

8.3 The aggregate of the material collected from the various increments or units samples from a sub-lot constitute a gross sample.

9 SAMPLING FROM STOCKPILES

9.1 Sub-lots

For the purpose of sampling, the quantity of iron ore in a stockpile shall be divided into a suitable number of sub-lots of approximately equal mass as specified in Table 1.

9.1.1 A representative gross sample shall be drawn from each of the sub-lots and shall be kept separately. Thus, there will be as many gross samples as the number of sub-lots into which the lot has been divided.

9.2 Sampling of ore from stockpiles shall be carried out, as far as possible when ore is in motion, that is, during the making or breaking of the stockpiles.

9.2.1 The number of increments to be taken from a sub-lot for making up the gross sample shall be governed by the mass of gross sample and the mass of the increments as specified in Table 2 for various categories of iron ore. This number shall be equally distributed over the sub-lot. The increment shall be drawn with the help of a suitable sampling scoop (*see* Fig. 1) at regular intervals in the course of making or unmaking of the stockpiles (*see also* **6.2.1**, Notes 1 and 2).

9.3 When it becomes necessary to sample a stockpile, sectional sampling (*see* **9.3.1**) and trench sampling method (*see* **9.3.2**) may be used for a stockpiles up to a maximum height 1.5 m only. In the former case, the requisite number of points shall be located at random on the entire surface of the sub-lots. In certain cases, due to practical constraints of space, material is stacked higher than 1.5 m, sometimes up to 3 m. In these cases, it may be required to sample such high stockpiles. Care must be taken to dig proper trench when sampling stacks of about 3 m height to ensure that the samples can be drawn from the exposed surfaces. The walking space at the ground level in this case must be kept at 0.5 m.

9.3.1 *Sectional Sampling of Stockpile of Height not More than 1 m*

By this method, at least 4 unit samples in the case of fine ores and 8 unit samples in the case of lumps are to be collected from each sub-lot. For this purpose, the requisite number of points shall be chosen at random on the entire surface of the stockpile. At each of the selected point, a circle of suitable diameter (minimum three times the largest particle size) shall be marked. The material over the area of this circle and along entire height of the stockpile from top to bottom shall be collected in stages. This can be carried out by taking ore up to a depth of 50 cm and covering the hole so formed by a plate for removing the ores lying on the sides of the hole. Then after removing the plate further depth can be reached in the same manner and the ore can be collected from the freshly formed hole.

9.3.2 *Trench Sampling*

This gross sample shall be made up of the number of increments as specified in Table 2. These increments shall be collected as indicated in **9.3.2.1**.

9.3.2.1 Along a randomly chosen line on the ore surface of the sub-lot, a trench shall be dug, right down to the ground level leaving about 0.3 m walking space at the ground level (at least 0.5 m, if the height of the stack is more than 1.5 m). From the trenches so dug, the required number of increment shall be collected with the help of a suitable sampling scoop, at various point randomly spread over the two exposed sides of the trenches. In case of large stockpiles, in addition to the trench, the sides of the piles may also be opened to expose the ore down to the bottom, at places where the trench does not expose the ore inside. For large stacks of about 3 m in height, at least 0.5 m of walking space should be kept at the ground level.

10 DETERMINATION OF SIZE DISTRIBUTION

10.1 The size distribution of iron ores fines in a lot shall be estimated as per IS 12550. In the determination of ore size distribution, IS sieves of suitable sizes specified in IS 460 (Part 1) and IS 460 (Part 2) shall be used. It is preferable to use perforated plate sives for sizes 5 mm and above. All sieves employed for sieving shall be of square aperatures only.

10.2 Gross Sample Obtained from Aggregating Unit Samples

Each gross sample shall be screened through selected IS sieves and the ore retained on each of the sieves and that passing through the smallest sieve shall be weighed separately. Ore size distribution of the lot shall be estimated as follows:

$$\text{Percentage mass in the size range 'A'} = \frac{a_1 + a_2 \ldots}{w_1 + w_2 \ldots} \times 100$$

where

$w_1, w_2\ldots$ = mass of the different gross sample, and

$a_1, a_2\ldots$ = corresponding masses of ore in the size range '*A*' (*A* may be below, above, or bounded by two nominal sizes of IS sieves).

10.3 Gross Samples Obtained by Aggregating Increments

10.3.1 Where gross samples do not contain any lumps, the procedure detailed in **10.2** shall be followed for estimating the ore size distribution in the lot.

10.3.2 Where the gross samples contain some lumps (*see* **6.2.1**, Notes 1 and 2) the portion of the gross samples excluding the lumps shall be treated as in **10.2.1**.

10.3.2.1 The ore size distribution of the lot shall be estimated as follows:

a) Over 200 mm, percent $= \dfrac{n \times 8}{(n \times 8) + w_1 + w_2 + w_3 + \ldots}$

b) Any other size fraction *B* $= \dfrac{b_1 + b_2 + b_3 + \ldots}{(n \times 8) + w_1 + w_2 + w_3 + \ldots}$

where

w_1, w_2 = mass of the different gross sample excluding the lumps *n* is the total number of lumps in all the gross samples, and

b_1, b_2 = mass of ore in the size range *B* in different gross samples.

NOTE — For lumps and sized ores, each lump picked up in the course of sampling is supposed to represent one increment of 8 kg.

11 REDUCTION OF GROSS SAMPLE

11.1 Each of the gross samples shall be first sent for determination of size distribution and only after that sample preparation shall be conducted. However, in the case of gross sample of fines, determination of size distribution may be carried out after reduction of gross sample. The stages of reducing gross sample from each sub-lot for preparing, physical test sample, chemical analysis sample and moisture sample are shown in flow chart given at Annex B and Annex C.

NOTES

1 If it is desired to draw separate moisture samples from each sub-lot, they shall be collected by drawing separate additional increments. Minimum number of increments for each moisture sample representing a sub-lot shall be 20 for lumps and 10 for fines. These additional increments shall be combined for each sub-lot and be kept in airtight containers with full details of sampling before they are sent for moisture sample preparation.

2 When the number of sub-lots constituting a lot is three or less, separate samples shall be drawn from physical tests parallel to the normal samples, so that about 200 kg of composite sample for the lot is available for sample preparation.

11.2 Preparation of Samples for Physical Test, Moisture and Chemical Analysis

Each gross sample shall be reduced separately. If physical test samples are required, ores of size greater than 40 mm size shall be first crushed in jaw crusher or manually using a hammer and manganese steel plate till all the ore passes 40 mm sieve. This ore shall be sampled or reduced to obtain 50 kg samples for physical test. In case physical test samples are not required, the stage of crushing to 40-mm shall be avoided, and the gross sample shall be crushed to pass 10 mm sieve. This shall then be further processed to stages detailed in Annex B to prepare laboratory final sample for chemical analysis and moisture determination. In case separate moisture samples are drawn they shall be crushed to pass 10 mm sieve and further processed as detailed in Annex B.

For bulk density tests, for ores of size above 40 mm, a sample of 20 tonne is required (as per IS 5842). In such case the sample for bulk density test, may be drawn independently, so as to obtain the required quantity of the test sample.

11.2.1 *Preparation of Physical Test Sample*

The physical test sample obtained from each gross sample of lumpy ore shall be combined together, and from this about 100 kg sample be derived preferably by increment division method. The physical test sample required to be prepared for various tests shall be processed as shown in Annex C. In case of fines, the sample left over after drawing moisture sample shall be used for physical test sample.

The gross sample for physical testing shall be divided, to prepare the test samples for the determinations of various physical properties, irrespective of division rules.

11.2.2 *Preparation of Moisture Sample*

From the moisture sample prepared from each gross sample, two samples of 1 kg each shall be obtained by increment reduction method after mixing the sample on a non-moisture absorbent surface. These samples shall be sealed in air-tight containers with suitable lid and sent for moisture determination.

11.2.3 *Laboratory Samples for Chemical Analysis*

The laboratory samples shall be obtained after the material is pulverized to pass through 150 microns

IS sieve. Each laboratory sample shall be minimum of 150 g. The material so obtained shall be divided into three or more equal parts, as requested by the purchaser, the supplier, the referee and others, if any. All the laboratory samples shall be preserved in dry, clean, and well-stoppered containers and labeled with full identification particulars like, source of the ore, category of the ore, supplier's name, the lot and sub-lot number and date of sampling.

11.3 Reduction of Samples

One or more of the following methods of sample reduction shall be used for dividing a gross sample or a composite sample:

a) Riffle division method,
b) Coning and quartering method, and
c) Increment reduction method.

11.3.1 *Riffle Division Method*

Depending upon the whole-through sieve size of the sample, an appropriate riffle divider specified in Table 3 shall be selected.

Table 3 Particle Size of Sample and Size of the Rifflers Divider

Sl No. (1)	Whole through Sieve Size Chutes mm (2)	Width of the Riffle Chute mm (3)	Number of Rifflers mm (4)
i)	40	90±1	12
ii)	10	30±1	12
iii)	5	10±1	16
iv)	2	6±0.5	16
v)	1	6±0.5	16

11.3.1.1 *Procedure*

The sample shall be mixed well and placed with a uniform thickness into the riffle tray and divided into almost equal parts carefully feeding the sample to the riffle uniformly, midway at right angles, across the length of the riffle chutes. Either of the two divided samples shall be selected at random each time the sample is reduced. The division shall be carried out in accordance with Table 4 and the sample shall not be divided further than the mass corresponding to the particle size specified in the table.

NOTES

1 Any material retained in the slots of the riffle shall be removed and added to the respective divided portion of the sample.

2 Sample receivers of the rifer shall properly fit the outlets of the riffle bench and shall be of such design as to ensure prevention of escaping fine particles from the divided parts.

3 Inside surface of the riffle divider shall be flat and smooth. The angle between the inclined surfaces of adjacent chutes shall be 60°.

4 This method is not applicable to divide samples, containing high moisture content, of sticky iron ores. However, samples may be sufficiently dried before division.

11.3.2 *Coning and Quartering Method*

The crushed ore shall be well mixed up and then scooped into a cone-shaped pile. Care should be taken to drop each scoopful exactly over the same spot as otherwise the central axis of the cone will be slackened and an uneven distribution of lumps and fines will results. After the cone is formed, it shall be flattened by pressing the top of the cone with the smooth surface of the scoop. Then it is cut into quarters by two lines, which intersect at right angles at the centre of the cone. The bulk of the sample is reduced by rejecting any two diagonally opposite quarters. The sample to be divided shall not be more the 10 mm as maximum particle size. The division shall be carried out as per Table 4.

Table 4 Minimum Mass of the Divided Sample by Riffle Division for Various Particle Sizes

(*Clauses* 11.3.1.1 *and* 11.3.2)

Sl No. (1)	Whole Through Over (2)	Sieve Sizes Up to mm (3)	Minimum Mass of the Sample After Division kg (4)
i)	30	40	300
ii)	5	10	10
iii)	2	5	5
iv)	1	2	3
v)	—	Less than 1	1

11.3.3 *Increment Reduction Method*

The crushed ore shall be spread on a smooth moisture non-absorbing plate into a uniform flat rectangular with the thickness specified in Table 5. The rectangular so formed shall be divided into 5 equal parts length-wise and 4 equal parts breadth-wise. From each of the 20 parts so obtained, equal quantities of the ore shall be collected by use of a suitable scoop once or more number of times depending upon the quantity of divided sample.

11.3.3.1 The method of increment reduction is recommended only when the division ratio is high. As such, in the illustration given in Table 2, this method can be applied in the initial stage when the gross sample is reduced and also at the final stage for obtaining laboratory samples and for obtaining duplicate moisture samples. Increment reduction method is preferred to other methods of sample reduction. Table 5 gives the thickness of layers of ores and the minimum mass of increment from each rectangular part, to be taken at one time with the use of a suitable scoop.

During the collection of sample, the scoop shall be thrust to the bottom of the sample layer. It is recommended that a flat bumper plate be thrust vertically in the sample layer in front of the scoop during collection. The dimension of the increment scoop to be used for various particle sizes of the sample is given in Table 5 and Fig.1. When the mass of the sample divided is expected to be smaller than that required for subsequent procedure, the mass of the increment and/or number of increment shall be increased. The minimum mass of the divided particle sizes of iron ore, samples shall be according to Table 4.

12 NUMBER OF TESTS

12.1 Moisture Sample

All the moisture samples representing a lot shall be tested individually for moisture content. Duplicate moisture determination shall be made for each sub-lot. To avoid any change in the moisture content, the moisture determination shall be done as quickly as possible, after the sample is taken. Moisture determination shall be determined as per IS 11690.

12.2 Sub-lot Laboratory Samples

All the sub-lot laboratory samples shall be tested individually for important chemical characteristics. For testing the remaining characteristics, a composite sample is prescribed in **3.11** shall be prepared and analyzed. The following scheme is recommended for chemical testing of iron ore:

12.2.1 Chemical constituent of the ore for which sub-lot samples are analyzed individually,

a) Fe content and any other chemical characteristics which is important or found variable A composite sample is analyzed.
b) Chemical constituent of the ore for which all the radicals stipulated in the contract.

13 REPORTING

13.1 For those characteristics where a composite sample has been tested, only one test results will be available and that result shall be reported as the value of the characteristics for the lot sampled.

13.1.1 When only two laboratory samples have been analyzed individually from a lot, the average of the two available test results shall be reported as the value of the characteristics for the lot sampled. In the case of sub-lots of approximately equal mass, this average shall be calculated as one half of the sum of two test results. If the sub-lots are of varying mass, then the weighted average shall be calculated as the sum of each test results multiplied by corresponding fraction got on dividing the sub-lot weight by the total weight. The individual results shall also be reported to give an indication of the range of variation in quality.

13.1.2 When three or more laboratory samples have been analyzed individually from a lot for any characteristics, the following procedure shall be followed to assess the average quality and its limits of variation:

Let x_1, x_2, x_3.... x_n be the results of analyzing n laboratory samples for a particular characteristics.

Calculate

Average $\bar{x} = \frac{x_1 + x_2 + x_3 + \ldots + x_n}{N}$, if sub-lots are of approximately equal mass

Or

$$\text{Weighted average } \bar{x} = \frac{w_1 x_1 + w_2 x_2 + w_3 x_3 + \ldots + w_n x_n}{w_1 + w_2 + w_3 + \ldots + w_n}$$

where w_1, w_2, w_3.... w_n are the mass of the sub-lots.

Table 5 Particle Sizes of Iron Ore, Thickness of Layer of Sample Spread Increment Scoop Dimensions and Increment Mass for Manual Increment Division

(*Clauses* 11.3.3 *and* 11.3.3.1)

Sl No.	Whole-Through Size mm		Thickness of Sample Spread mm	Scoop Number	Dimensions of Increment Scoop mm				Approximate Increment Mass kg
	Over	Up to			*A*	*B*	*C*	*D*	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
i)	30	40	80	40D	180	180	120	150	9.000
ii)	5	10	30	10D	75	75	40	60	0.500
iii)	2	5	20	5D	50	50	30	40	0.160
iv)	1	2	15	2D	40	40	25	30	0.100
v)	Less than 1		10	1D	25	25	20	20	0.030

Range $\bar{R}$ = difference between the maximum and minimum of the values (when n is less than 10)

Or $\bar{R}$ = the average value of ranges. When the number of sub-lots n is equal to 10 or more, the corresponding results on laboratory samples (10 or more) should be constituted into two groups in order of their occurrence. For each group, range (R) should be calculated and the average value ($\bar{R}$) of the R's should be used in the subsequent clause.

The average level of the characteristics in the lot shall be reported a equal to (x).

The limits of variation in the average level of the lot at 95 percent probability shall be reported as $\left(\bar{x} \pm h\bar{R}\right)$, where h is a factor, the value of which depends on the number of samples anlayzed. The appropriate value of the factor h shall be taken from the following table:

No. of Laboratory Samples Analyzed	*Value of the Factor*
3	1.30
4	0.72
5	0.51
6	0.40
7	0.33
8	0.29
10	0.31
12	0.25
15	0.24
16	0.19
18	0.17
21	0.17
27	0.13

NOTE — If the number of laboratory samples are different from those given above, it is recommended to obtain the factor '*h*' for determining confidence limits for the average, using samples standard derivation from Table 5 of IS 1548.

ANNEX A

(*Table* 2)

EXPERIMENTAL METHODS FOR EVALUATION OF QUALITY VARIATION

A-1 QUALITY VARIATION

A-1.1 The magnitude of quality variation or degree of heterogeneity of iron ores shall be determined by standard deviation which for stratified sampling, it shall be in the stratum and for periodic systematic sampling, it shall be between the increments in the sampling interval. The standard deviation within strata or intervals between taking increments is denoted by σ_w.

The quality variation shall be investigated for each brand of the ore.

A-1.2 Quality Characteristics

The quality characteristics chosen for determining the quality variation is generally the total iron content. However, the moisture content, particle size and other quality characteristics can also be selected.

A-1.3 Sampling, Sample Preparation and Measurement

These shall be carried out in accordance with this standard, IS 1493 and IS 11690.

A-2 INVESTIGATION METHOD

A-2.1 Deviation of methods shall be as indicated below:

a) *Method I* — When the experiment is carried out on a particular consignment or lot, it shall be divided at least into 10 strata, with nearly the same mass. The increments (equal in number) from each stratum are collected in accordance with the method given below (*see also* Annex D, Example 1) and take them as a group of sub-samples (the number of increments shall be even). Example for one lot divided into 10 strata is given at Annex D:

(○) A_1 (○) B_1	(○) A_2 (○) B_2	(○) A_3 (○) B_3	(○) A_4 (○) B_4	(○) A_5 (○) B_5
(○) A_6 (○) B_6	(○) A_7 (○) B_7	(○) A_8 (○) B_8	(○) A_9 (○) B_9	(○) A_{10} (○) B_{10}

NOTES

1 The rectangular box represents one lot and each division represents one stratum.

2 ○ represents the sub-sample.

3 Note 1 and Note 2 apply to Method II and Method III also.

b) *Method II* — When the quality variation is to be obtained from several number of large lots, of nearly equal mass, equal number of increments from each stratum shall be collected in accordance with the method given below (*see also* Annex D, Example 2): The increments in each group of sub-samples shall be even. Example of 3 lots divided into 12 strata is given at Annex D.

Lot 1	A_1 ○ B_1 ○	A_2 ○ B_2 ○	A_3 ○ B_3 ○	A_4 ○ B_4 ○

Lot 2	A_5 ○ B_5 ○	A_6 ○ B_6 ○	A_7 ○ B_7 ○	A_8 ○ B_8 ○

Lot 3	A_9 ○ B_9 ○	A_{10} ○ B_{10} ○	A_{11} ○ B_{11} ○	A_{12} ○ B_{12} ○

c) *Method III* — When the increments are taken from all of the primary sampling units (wagons or barges). Equal number of increments of each sub-lot shall be collected in accordance with the method as shown in Fig. 3 (*see also* Annex D, Example 3). The number of increments in each group of sub-samples shall be even.

A-2.2 Composition of Sub-samples

The composition of sub-samples shall be in accordance with the following procedure.

A-2.2.1 Assign consecutive numbers in the order of taking to the increments of one stratum.

A-2.2.2 Collect the increments having an odd number from each stratum, taken them as the sub-sample *A* and collect the increments having an even number, take them as one group of sub-sample *B* and constitute a pair of the sub-samples (*see* Fig. 4).

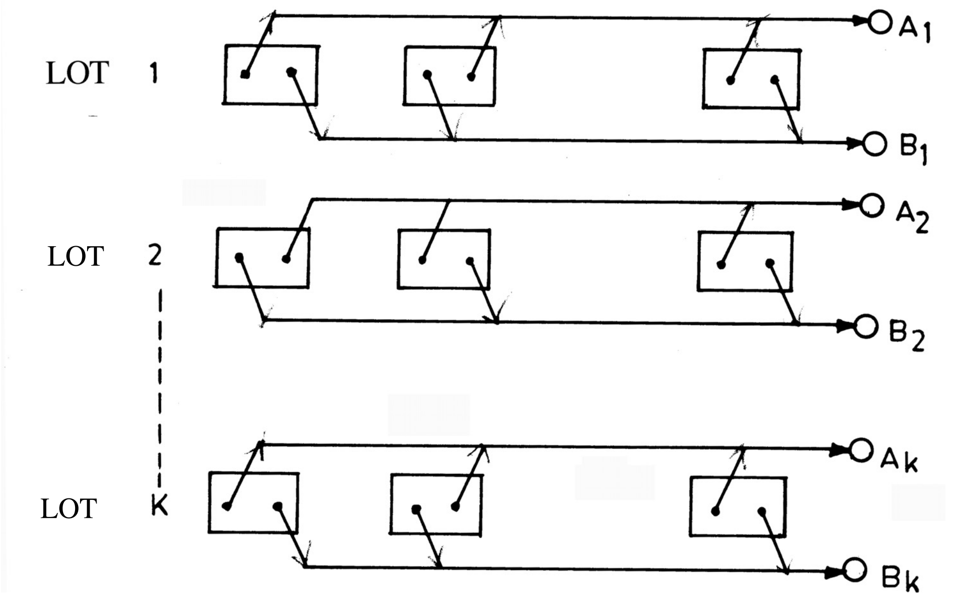
A-2.2.3 For each of Methods I to III prepare *k* groups of paired sub-samples.

NOTE — Each sub-sample shall be constituted of not less than 2 increments.

A-3 PREPARATION OF TESTS SAMPLE AND MEASUREMENT

Prepare the test sample from the sub-sample A_i, and B_i of each stratum.

Use the test sample for the measurement of required quality characteristics (chemical constituent, moisture content, particle size and physical characteristics as the quality characteristics.

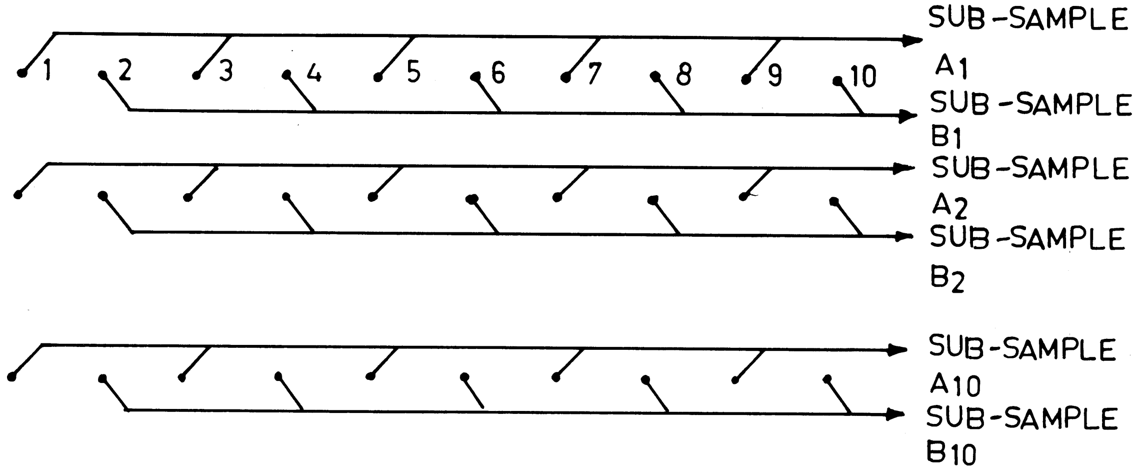


NOTES

1 The rectangular box represents the primary sampling unit.

2 The mark (o) represents the sub-sample and the mark (·) represents the increment.

Fig. 3 Method III (Example of Stratified Sampling of Freight Car — Loaded Lot)



NOTES

1 The mark (●) represents the increment.

2 The above figure is an example of investigation for a certain one lot and the minimum required number of increments in accordance with this standard, is 100 increments, and 10 groups of sub-sample A_i and B_i constituting each sub-sample by 5 increments shall be prepared.

Fig. 4 Composition of Sub-samples (Example of Method I)

A-3.1 Number of Investigations

The number of investigations has been determined as the following because the standard deviation σ_w can not be estimated with sufficient precision when the number of investigations is small.

a) In the case of Method I and Method II, at least 5 times of investigation are required.

b) In the case of Method III, at least 10 times of investigations are required.

A-4 CALCULATION OF STANDARD DEVIATION IN STRATUM

A-4.1 Recording of Measurement Results

Record the results of the chemical analysis, moisture content measurement, particle size measurement and physical test which have been measured for each test sample on the data sheet of unified form (*see also* Annex D, Examples 1 to 3).

A-4.2 Calculation

The estimated value of the standard deviation in the stratum shall be calculated according to the following formula:

Range of pair data:

$$R = |A - B| \qquad \ldots (1)$$

where

A = data of quality characteristics of the test sample prepared from sub-sample A; and

B = data of quality characteristics of the test sample prepared from sub-sample B.

Average of the ranges:

$$R = \frac{1}{k}\Sigma R \qquad \ldots (2)$$

where

k = number of range R.

Average of pair data:

$$\bar{x} = (1/2)\,(A+B) \qquad \ldots (3)$$

Standard deviation in the stratum:

$$\hat{\sigma}_w = \sqrt{n_s}\,\frac{\bar{R}}{d_2} \qquad \ldots (4)$$

where

$\hat{\sigma}_w$ = estimated value of the standard deviation in the stratum;

n_s = number of increments constituting each sub-sample A or B; and

d_2 = 1.128 4.

NOTES

1 As the decision value of daily quality characteristics of lot, the average value ($\bar{x}$) of that lot may be obtained from the formula (5):

$$\bar{x} = \frac{1}{k}\Sigma x_i \qquad \ldots (5)$$

2 $\hat{\sigma}_w$ obtained from the formula (4) is the standard deviation including sampling, sample preparation and measurement hence $\hat{\sigma}_w$ is overestimated. However, this value may be used to classify the quality variation in **6**.

A-5 EXPRESSION OF RESULTS

A-5.1 In case of Method I and Method II, the estimated value $\hat{\sigma}_w$ of the standard deviation in the stratum obtained from serial investigations shall be reported by the square root of average value of all $\hat{\sigma}_w{}^2$.

$$\bar{\hat{\sigma}}_w = \sqrt{\frac{1}{h}\Sigma\,\hat{\sigma}_w{}^2} \qquad \ldots (6)$$

where

$\bar{\hat{\sigma}}_w$ = average value of $\hat{\sigma}_w$, and

h = number of $\hat{\sigma}_w{}^2$.

A-5.2 In the case of Method III, the value of $\bar{\hat{\sigma}}_w$ obtained from the formula (4) or the value of $\bar{\hat{\sigma}}_w$ obtained from the formula (6) shall be taken as the estimated value of the standard deviation in the stratum.

A-6 CLASSIFICATION OF QUALITY VARIATION

The quality variation of particulate materials shall be classified according to Table 7.

Table 7 Classification of Quality Variation σ_w (Valued as Absolute Percentages)

Sl No. (1)	Quality Characteristics (2)		Classification of Quality Variation (σ_w) Large (3)
i)	Iron content		$\sigma_w \geq 2.0$
ii)	Silica content		$\sigma_w \geq 2.0$
iii)	Alumina content		$\sigma_w \geq 0.6$
iv)	Phosphorus content		$\sigma_w \geq 0.015$
v)	Moisture content		$\sigma_w \geq 2.0$
vi)	Size of –200 mm ore Size of –50 mm ore	–10 mm fraction mean 20 percent	$\sigma_w \geq 10$
vii)	Size of –31.5+6.3 mm ore	–6.3 mm fraction mean 10 percent	$\sigma_w \geq 5$
viii)	Size of sinter feed	+ 6.3 mm fraction mean 10 percent	
ix)	Size of pellet feed	–45 µm fraction mean 70 percent	$\sigma_w \geq 3$

NOTE — The quality variation has possibility of change by the following factors:

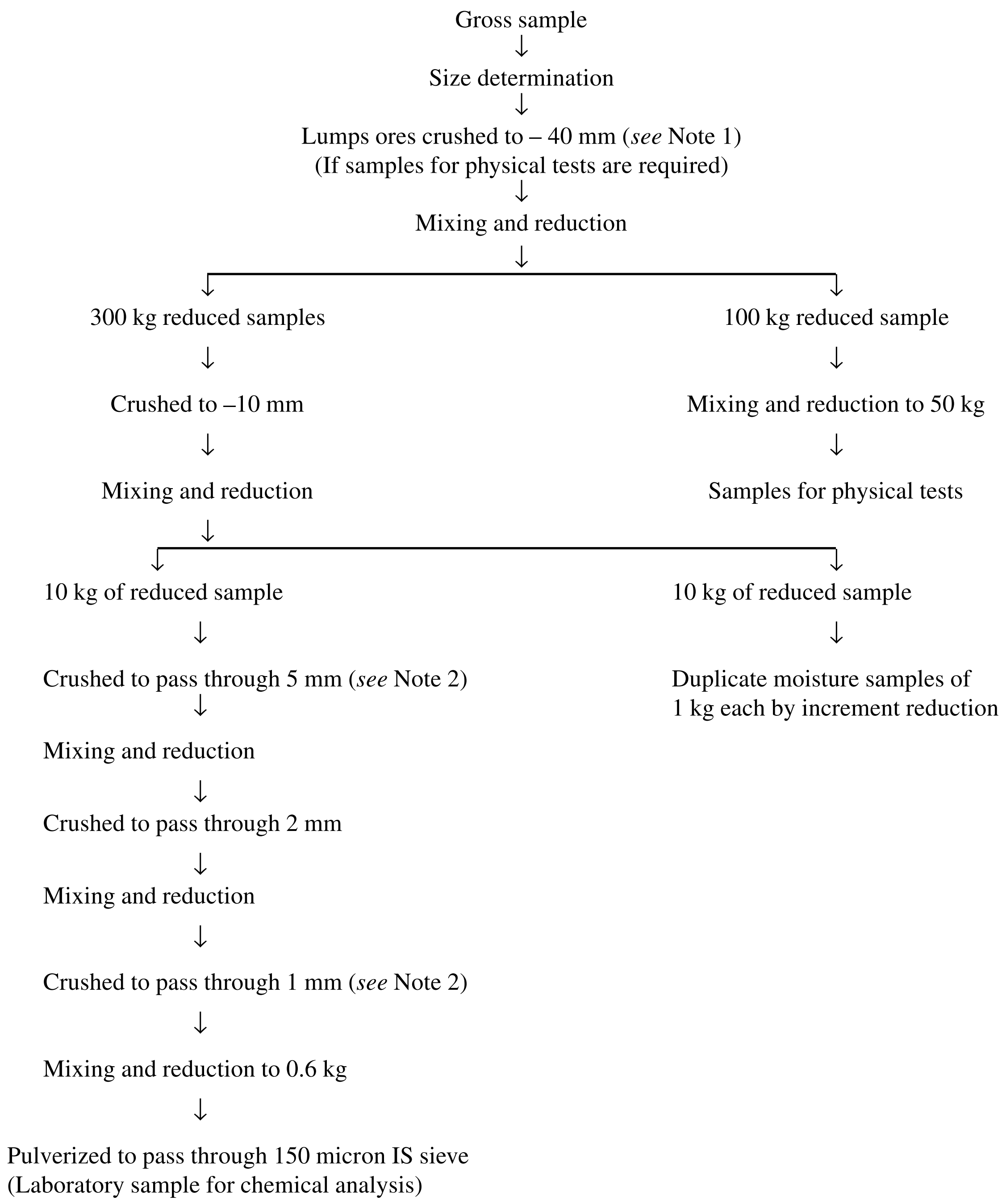
a) Ore deposits of mine,
b) Mining method,
c) Methods of ore dressing,
d) Methods of stock pile and delivery,
e) Method of stevedoring, and
f) Method of ore blending.

Therefore, the quality variation shall be checked frequently to confirm the influences by the above changes.

ANNEX B

(*Clauses* 11.1 *and* 11.2)

STAGES IN SAMPLE PREPARATION OF A GROSS SAMPLE


Gross sample
Size determination
Lumps ores crushed to – 40 mm (*see* Note 1)
(If samples for physical tests are required)
Mixing and reduction
300 kg reduced samples
100 kg reduced sample
Crushed to –10 mm
Mixing and reduction to 50 kg
Mixing and reduction
Samples for physical tests
10 kg of reduced sample
10 kg of reduced sample
Crushed to pass through 5 mm (*see* Note 2)
Duplicate moisture samples of
1 kg each by increment reduction
Mixing and reduction
Crushed to pass through 2 mm
Mixing and reduction
Crushed to pass through 1 mm (*see* Note 2)
Mixing and reduction to 0.6 kg
Pulverized to pass through 150 micron IS sieve
(Laboratory sample for chemical analysis)

NOTES

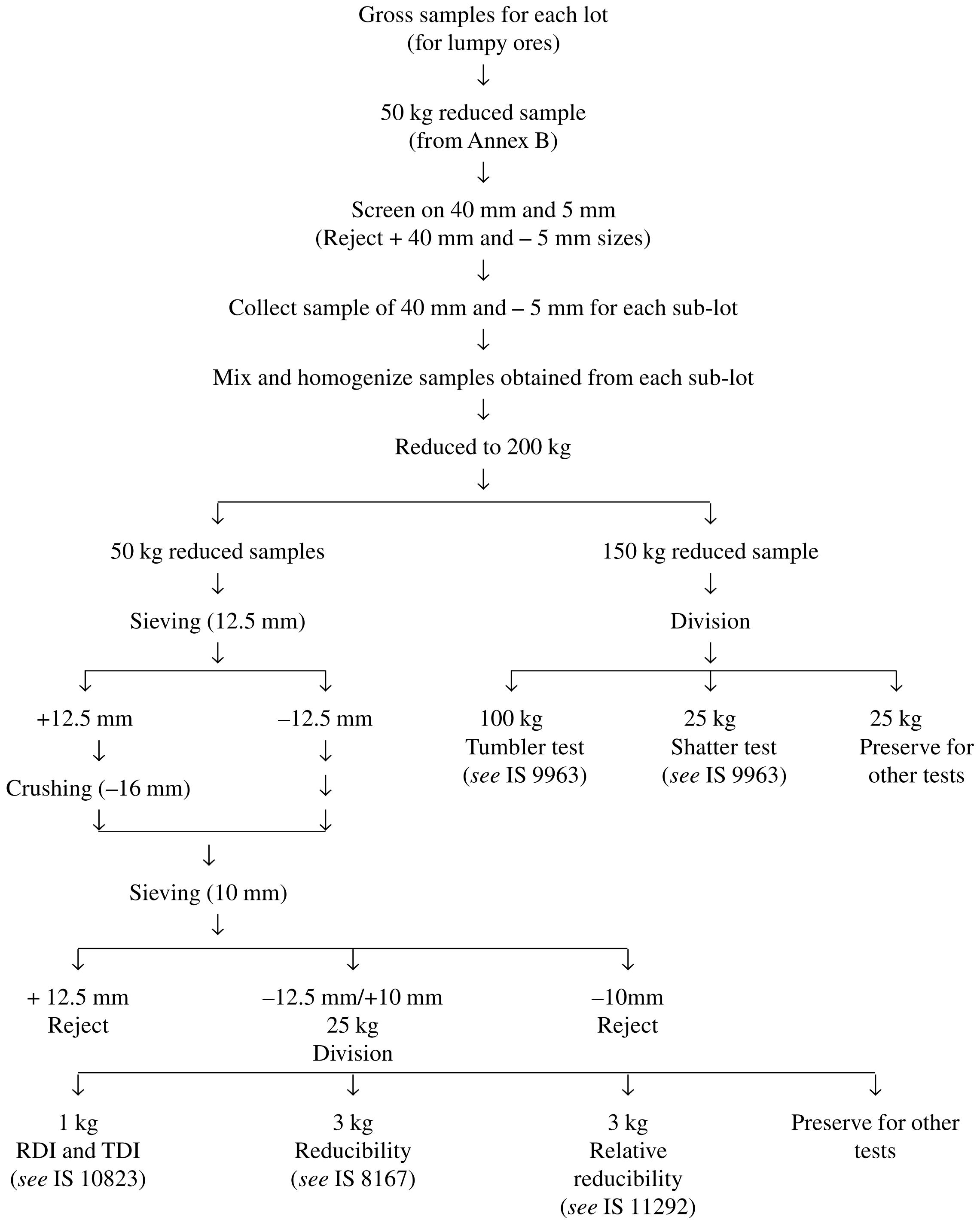
1 The sample of fine ores and lumpy ores, if physical tests are not required shall be crushed to –10 mm and further stages of sample preparation shall be carried out.

2 Stages of crushing to –5 mm and to –1 mm size may be bypassed.

ANNEX C

(*Clauses* 11.1 *and* 11.2.1)

STAGES IN PREPARING SAMPLES FOR PHYSICAL TESTS



NOTE — For fines ores, samples after moisture tests (as shown in Annex B) to be taken for physical tests.

ANNEX D

(*Clauses* A-2.1 *and* A-4.1)

EXAMPLE FOR CALCULATIONS OF STANDARD DEVIATION

Example 1: Stratified sampling of one lot

Sl No. (1)	*Details of Lot* (2)	*Details of Sampling* (3)
i)	Name of ore (Iron ore)	Mass of increment : 4 kg
ii)	Brand of ore	Number of increment : 120
iii)	State of ore (Lump ore)	Number of strata : 10
iv)	Constitution of lot (Name of ship)	Number of increments constituting the sub-sample : $n_s = \frac{120}{10 \times 2} = 6$
v)	Date of arrival of goods	
vi)	Mass of lot (50 000 t based on wet ore)	

No. of Stratum	**–10 mm (Undersieve)** Percent				**Moisture Content** Percent				**Total Iron Content** Percent			
	A	*B*	$\bar{x}$	*R*	*A*	*B*	$\bar{x}$	*R*	*A*	*B*	$\bar{x}$	*R*
1	30.2	35.5	32.8	5.3	5.75	6.06	5.90	0.31	60.95	61.61	61.28	0.66
2	27.8	34.7	31.2	6.9	6.17	5.90	6.04	0.27	62.29	61.42	61.86	0.87
3	24.7	19.6	22.2	5.1	5.90	6.48	6.19	0.58	61.97	62.90	62.44	0.93
4	22.4	26.3	24.4	3.9	6.10	6.43	6.26	0.33	61.77	62.45	62.11	0.68
5	13.3	7.9	10.6	5.4	5.24	4.60	4.92	0.64	64.62	63.48	64.05	1.14
6	19.7	29.2	24.4	9.5	5.95	6.92	6.44	0.97	63.00	62.13	62.64	1.03
7	28.1	14.3	21.2	13.8	6.26	5.20	5.73	1.06	62.38	63.60	62.99	1.22
8	9.4	14.3	11.8	4.9	4.65	5.38	5.02	0.73	63.98	63.09	63.54	0.89
9	14.0	16.1	15.0	2.1	5.39	5.10	5.24	0.29	63.26	64.80	64.03	1.54
10	17.3	13.1	15.2	4.2	4.95	5.31	5.13	0.36	62.31	63.24	62.78	0.93
$\bar{\bar{x}} = \frac{1}{10} S\bar{x}$	—	—	20.9	—	—	—	5.69	—	—	—	62.77	—
$\bar{R} = \frac{1}{10} SR$	—	—	—	6.11	—	—	—	0.554	—	—	—	0.989
$\hat{s}^2_w = s\left(\bar{R}'\ 0.886\,2\right)^2$	—	—	—	175.912 7	—	—	—	1.446 2	—	—	—	4.609
$\hat{s}_w$	—	—	—	13.3	—	—	—	1.20	—	—	—	2.15

Example 2: Stratified sampling of four lot

Sl No. (1)	*Details of Lot* (2)	*Details of Sampling* (3)	
i)	Name of ore (Iron ore)	Mass of increment	: 4 kg
ii)	Brand of ore	Number of strata of each lot	: 3
iii)	State of ore (Fine ore)	Number of increments constituting the sub-sample	: $n_s = \frac{60}{3 \times 2} = 10$

No. of Lot	Constitution of Lot (Example: Ship's Name)	Date of Arrival of Cargo	Mass of Lot (Based on Wet Ore) *t*	Number of Increments *n*
1	—	—	21 459	60
2	—	—	20 964	60
3	—	—	21 400	60
4	—	—	21 750	60

No. of Stratum	No. of Lot	–10 mm (Undersieve) Percent				Moisture Content Percent				Total Iron Content Percent			
		A	*B*	$\bar{x}$	*R*	*A*	*B*	$\bar{x}$	*R*	*A*	*B*	$\bar{x}$	*R*
1	1	46.8	51.1	49.0	4.3	5.46	6.10	5.78	0.64	62.31	61.44	61.88	0.87
2		44.7	35.4	40.0	9.3	5.69	5.23	5.46	0.46	63.22	61.86	62.54	1.36
3		38.2	35.1	36.6	3.1	5.47	5.16	5.32	0.31	62.15	63.19	62.67	1.04
4	2	51.2	47.2	49.2	4.0	5.44	5.01	5.22	0.43	62.79	62.22	62.50	0.57
5		44.0	41.2	42.6	2.8	5.47	5.12	5.30	0.35	62.08	62.92	62.50	0.84
6		30.9	36.3	33.6	5.4	5.54	4.87	5.20	0.67	63.22	62.57	62.90	0.65
7	3	42.4	38.9	40.6	3.5	5.62	5.42	5.52	0.20	64.42	63.28	63.85	1.14
8		33.7	37.3	35.5	3.6	5.23	5.07	5.15	0.16	63.14	64.01	63.58	0.87
9		25.3	30.7	28.0	5.4	5.01	5.33	5.17	0.32	64.94	63.98	64,93	0.97
10	4	44.5	42.4	43.4	2.1	4.49	4.33	4.41	0.16	64.30	63.56	63.93	0.74
11		37.9	33.2	35.6	4.7	4.34	4.58	4.46	0.24	64.33	65.65	64.99	1.32
12		25.9	32.2	29.0	6.3	4.85	4.37	4.62	0.47	64.12	65.25	64.68	1.13
$\bar{\bar{x}}_1 = \frac{1}{3} \sum \bar{x}_1$		—	—	41.9	—	—	—	5.52	—	—	—	62.37	—
$\bar{\bar{x}}_2 = \frac{1}{3} \sum \bar{x}_2$		—	—	41.8	—	—	—	5.24	—	—	—	62.63	—
$\bar{\bar{x}}_3 = \frac{1}{3} \sum \bar{x}_3$		—	—	34.7	—	—	—	5.28	—	—	—	63.96	—
$\bar{\bar{x}}_4 = \frac{1}{3} \sum \bar{x}_4$		—	—	36.0	—	—	—	4.50	—	—	—	64.53	—
$\bar{R} = \frac{1}{12} \Sigma R$		—	—	—	4.54	—	—	—	0.368	—	—	—	0.958
$\hat{\sigma}_w^2 = \sigma\left(\bar{R} \times 0.886\,2\right)^2$		—	—	—	161.873 3	—	—	—	1.063 5	—	—	—	7.207 7
$\hat{\sigma}_w$		—	—	—	12.7	—	—	—	1.03	—	—	—	2.69

Remarks: x_1, x_2…., correspond to the lots of No. 1, 2, ……, respectively.

Example 3: Stratified sampling of 13 sub-lot

Sl No. (1)	*Details of Lot* (2)	*Details of Sampling* (3)
i)	Name of ore (Iron ore)	Mass of increment : 8 kg
ii)	Brand of ore	
iii)	State of ore (Lump ore)	
iv)	Mass of the consignment 37 500 t	

No. of Lot	**Constitution of Lot (Example: Ship's Name)**	**Date of Arrival of Cargo**	**Mass of Lot (Based on Wet Ore)** t	**Number of Increments** n	**Number of Increments Constituting Sub-sample** $n_s = \frac{20}{2} = 10$
1	—	—	3 023	20	10
2	—	—	2 998	20	10
3	—	—	2 895	20	10
4	—	—	2 824	20	10
5	—	—	2 834	20	10
6	—	—	2 825	20	10
7	—	—	2 182	20	10
8	—	—	3 040	20	10
9	—	—	2 925	20	10
10	—	—	3 028	20	10
11	—	—	2 218	20	10
12	—	—	3 056	20	10
13	—	—	3 100	20	10

No. of Lot	**–10 mm (Undersieve)** Percent				**Moisture Content** Percent				**Total Iron Content** Percent			
	A	B	$\bar{x}$	R	A	B	$\bar{x}$	R	A	B	$\bar{x}$	R
1	30.9	39.2	35.0	8.3	5.99	6.06	6.02	0.07	60.25	60.50	60.38	0.25
2	31.5	35.2	33.4	3.7	5.37	5.81	5.59	0.44	61.80	61.60	61.70	0.20
3	38.1	42.1	40.1	4.0	5.44	5.63	5.54	0.19	61.10	61.20	61.15	0.10
4	37.8	37.2	37.5	0.6	4.70	4.58	4.64	0.12	62.05	62.00	62.02	0.05
5	42.7	40.3	41.5	2.4	4.83	4.96	4.90	0.13	61.58	61.50	61.54	0.08
6	26.0	26.7	26.4	0.7	5.05	5.26	5.16	0.21	62.20	61.65	61.92	0.55
7	36.0	38.3	37.2	2.3	5.61	5.67	5.64	0.06	61.35	61.10	61.22	0.25
8	31.7	38.2	35.0	6.5	5.11	5.53	5.32	0.42	62.00	62.20	62.10	0.20
9	41.0	34.7	37.8	6.3	3.75	3.73	3.74	0.02	64.25	64.40	64.32	0.15
10	15.9	20.1	18.0	4.2	5.46	5.42	5.44	0.04	63.30	63.30	63.30	0.00
11	16.7	19.5	18.1	2.8	5.00	5.16	5.08	0.16	64.05	64.15	64.10	0.10
12	25.0	23.4	24.2	1.6	5.64	5.48	5.56	0.16	62.85	63.05	62.95	0.20
13	30.0	34.8	32.4	4.8	5.75	5.75	5.75	0.00	59.60	59.20	59.40	0.40
$\bar{\bar{x}} = \frac{1}{13} S\bar{x}$	—	—	32.0	—	—	—	5.26	—	—	—	62.01	—
$\bar{R} = \frac{1}{13} \Sigma R$	—	—	—	3.71	—	—	—	0.155	—	—	—	0.195
$\hat{s}_w^2 = 10\left(\bar{R}' \ 0.886\,2\right)^2$	—	—	—	108.096	—	—	—	0.188 7	—	—	—	0.298 6
$\hat{\sigma}_w$	—	—	—	10.4	—	—	—	0.43	—	—	—	0.55

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act*, 1986 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Copyright

BIS has the copyright of all its publications. No part of these publications may be reproduced in any form without the prior permission in writing of BIS. This does not preclude the free use, in the course of implementing the standard, of necessary details, such as symbols and sizes, type or grade designations. Enquiries relating to copyright be addressed to the Director (Publications), BIS.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards : Monthly Additions'.

This Indian Standard has been developed from Doc No.: MTD 13 (4667).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones : 2323 0131, 2323 3375, 2323 9402 *Website*: www.bis.org.in

Regional Offices:		*Telephones*
Central	: Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110002	2323 7617 2323 3841
Eastern	: 1/14 C.I.T. Scheme VII M, V. I. P. Road, Kankurgachi KOLKATA 700054	2337 8499, 2337 8561 2337 8626, 2337 9120
Northern	: SCO 335-336, Sector 34-A, CHANDIGARH 160022	60 3843 60 9285
Southern	: C.I.T. Campus, IV Cross Road, CHENNAI 600113	2254 1216, 2254 1442 2254 2519, 2254 2315
Western	: Manakalaya, E9 MIDC, Marol, Andheri (East) MUMBAI 400093	2832 9295, 2832 7858 2832 7891, 2832 7892

Branches: AHMEDABAD. BANGALORE. BHOPAL. BHUBANESHWAR. COIMBATORE. DEHRADUN. FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. KANPUR. LUCKNOW. NAGPUR. PARWANOO. PATNA. PUNE. RAJKOT. THIRUVANANTHAPURAM. VISAKHAPATNAM.

Laser Typeset by Sunshine Graphics